Arizona Department of Agriculture
AILRC Grants Program – Final Report for 2003-2004
September 2004

Management of Aphids And Thrips In Desert Head Lettuce

John C. Palumbo
University of Arizona, Yuma Valley Agricultural Center

Introduction

Desert lettuce production remains highly dependant on the availability of effective and economical insecticides. The implementation of FQPA has begun and will likely result in the reduced availability of many important compounds. Consequently, development of new IPM alternatives for insect management has become especially important. Recent product registrations have resulted in important IPM tools for desert lettuce growers that provide excellent control of worms, *leafminers*, and whiteflies. There are several additional chemistries currently under development that will be available for insect management in the next few years. Research to evaluate and develop these products for desert lettuce IPM programs has been supported through funding provided by AILRC and the Agrochemical industry over the past several years.

However, thrips and aphids still remain key pests of spring lettuce in the desert and represent the most important insect problems currently facing the industry. Several new promising insecticides that are in early stages of development are being evaluated for their control. However, the presence of a new aphid species, the currant-lettuce aphid, *Nasonovia ribisnigri*, and the foxglove aphid, *Aulacorthum solani*, presents some new challenges. We are still uncertain how this new species will behave under desert growing conditions. Research to learn more about its damage potential and control in the desert needs to continue. Furthermore, western flower thrips remain a very difficult pest to control and no compounds are being developed specifically for its management. Many of the compounds currently used for controlling thrips (Lannate, Orthene, Dimethoate) are directly threatened by FQPA. The intention of this proposal is to continue evaluation of new chemistries and management approaches under local growing conditions and generate new information that will allow Arizona growers to cost-effectively manage these pests.

Aphids are one of the most important insect problems in head lettuce grown in Arizona. A new aphid species, the foxglove aphid, *Aulacorthum solani*, was found infesting commercial lettuce fields in the Yuma area for the first time this past growing season. It has been known to occur in California since at least 1940, and along with the lettuce aphid, *Nosanovia ribis-nigri*, has caused problems for lettuce growers in Salinas area for the past several years. Although, the lettuce aphid is the more important of the two in Salinas, studies last spring suggest that foxglove aphid may be a more important pest in the desert. Foxglove aphids are thought to occur throughout the U.S and Canada, but its effect is generally greatest in the eastern regions of the continent. It is also found worldwide, but is probably of European origin.

The foxglove aphid appears to be similar to the lettuce aphid in that the alates (winged forms) are difficult to differentiate, both aphids have short life cycles that allow populations to build up rapidly, and both tend to prefer to colonize the youngest tissue near the terminal growing point of the plant. Apterae (wingless forms) foxglove aphid are also often confused with the green peach aphid, *Myzus persicae*. Both aphids are usually yellow-green to all green but the green peach aphid may also be somewhat pink or red, as is the lettuce aphid. The foxglove aphid is slightly larger (maximum length is 3.0 mm) than the green peach aphid (max. length is 2.3 mm). One way to distinguish these two aphids is by the dark joints found on legs and antennae of the foxglove aphid, and the dark tips of the cornicles. The green peach aphid also has pale-colored legs and antennae but without dark joints. Foxglove aphids are also unique in that they have a bright green or dark colored spot at the base of each cornicle. Alates have a pattern of transverse dark bars on the dorsal abdomen.

The foxglove aphid was not previously thought to occur in Arizona. It is principally considered a serious pest of potatoes and is also found on ornamental and greenhouse plants. It is considered an occasional pest of lettuce and leafy vegetables grown in Canada. Unlike the lettuce aphid which was first found in Yuma five years ago, the foxglove aphid is known to colonize a much broader range of plant hosts, including a wide variety of weeds, ornamentals and crops. This large availability of hosts and apparent adaptation to our winter and spring growing conditions suggests that foxglove aphids might present growers with some new challenges.

There is much uncertainty surrounding this new species, and its ability to thrive within our desert growing conditions. We are not sure how or when the foxglove aphid moved into the Yuma area, but it seems likely that it may have arrived via transplants or harvest equipment, much like we suspect with the lettuce aphid. Because this species is polyphagus and utilizes a number of known host plants grown in the desert, we are concerned that foxglove aphids may become an established pest on our winter/spring crops. In terms of management, control with foliar aphicides appears to be more difficult because the aphids preference for the protected terminal growth. We have had the opportunity to conduct a considerable amount of field research over the past two growing seasons to learn more about this pest. Because of the importance of the foxglove as a contaminant of lettuce and other leafy vegetables, we designed several studies to its examine its population growth, distribution, and damage potential.

<u>Objective 1.</u> Impact of Planting Date on Aphid Infestations and Contamination in Head Lettuce

Materials and Methods

To examine the population dynamics and damage potential of aphid species across five planting dates, experimental field plots were established in head lettuce at the University of Arizona, Yuma Agricultural Center. Beginning in mid-October 1999, 0.2 acre plots of head lettuce were planted on 2-3 week intervals. Table 1 provides the planting date and lettuce variety for each planting in each year of the study . On each planting date (wet date) lettuce was direct seeded into double row beds on 42 inch centers. Each planting was subdivided into 4 plots consisted of 4 beds, 150 feet long. Plots were arranged in a randomized complete block design with four replications. No insecticide applications were made during the study.

Aphid populations were assessed by estimating the number of aphids/plant by taking whole plant destructive samples. On each sampling date, 10 plants were randomly selected from each plot and placed individually into large 4-gal tubs. Each plant was sampled by visually examining all plant foliage and counting the number of alate and apterous aphids present. At harvest, infestation levels of apterous aphids were estimated by randomly selecting 10 plants within each replicate, visually counting the number of aphids on frame/wrapper leaves and heads, and separately recording aphid numbers for each location. Weather data observed from the AZMET station at the Yuma Ag Center was used to examine the influence of temperature and rainfall on foxglove abundance and population growth.

Results and Discussion

Seasonal aphid abundance and timing of infestation for each planting date for the 5 growing season is shown in figures 1-4. Population growth and head contamination varied among the species and was influenced in part by weather occurring during each planting (Table 1). Green peach aphid has traditionally been the most abundant and economically important aphid species infesting desert lettuce. However, GPA occurred only sporadically during the first four years of this study (Figure 1). Last season though, GPA reached very high population levels in the October plantings, and crashed with the high temperatures that occurred in March. Economic head contamination by GPA was recorded only in the 30 Oct planting date (Table 1). Based on a summary of the past 5 years, the lettuce crops at most risk from GPA were during the late-October and early-November planting windows (Table 2).

PA and AL aphids have varied in abundance among planting dates over the past 5 years (Fig 2). Similarly they varied in abundance from year to year, peaking in the spring of 2003. Head contamination by PA and AL was only observed in 2001 and 2003 (Table 1). Last season, PA and AL infestations were extremely light showing up in the late Oct planting at sub-threshold densities. Similarly, head contamination by these species was not economic in 2004. Overall these species appear to be most abundant in the late-November and December plantings (Table 3). LA was first observed in the Yuma area and in our studies in 1999. Since then they have been sporadically abundant during each year (Figure 3). However, LA infestations were quite damaging to heads in the spring 2003, and almost exclusively in the December plantings (Table 1). Because this aphid species tends to prefer higher temperatures, the lettuce plantings that are seeded in Decemeber and harvest in March appear to be at most risk from LA. (Table 4).

FG aphids first appeared in our lettuce trials 3 years ago and have continued to increase their abundance in each successive season (Figure 4). Their numbers were quite high during the 2003 season and appeared to be increasing to even higher number in 2004 but declined in the later plantings due to the high temperatures we experienced in March. Based on the limited 3 years of data, this species has the potential to cause economic contamination of heads in November and December plantings (Table 1) and consequently, appears to have the potential to be at rsik to lettuce crops planted during November and December (Table 5).

In conclusion, the data generated from this study clearly demonstrates that a multiple complex of economic aphid species occurs in desert lettuce. This complex is capable of causing economic damage through contamination to lettuce heads in direct seeded plantings from late October through December. Because aphid abundance and timing of infestations varies from species to species, proper identification will be important for management. This is due in part because aphid susceptibility to different classes of insecticides varies between species. In addition, it is further recommended that growers should begin applying soil systemic insecticides such as Admire (imidacloprid) for aphid control beginning in late October and continuing until planting is over in December.

Figure 1. Green peach aphid populations in head lettuce in 5 plantings each year from 1999-2004.

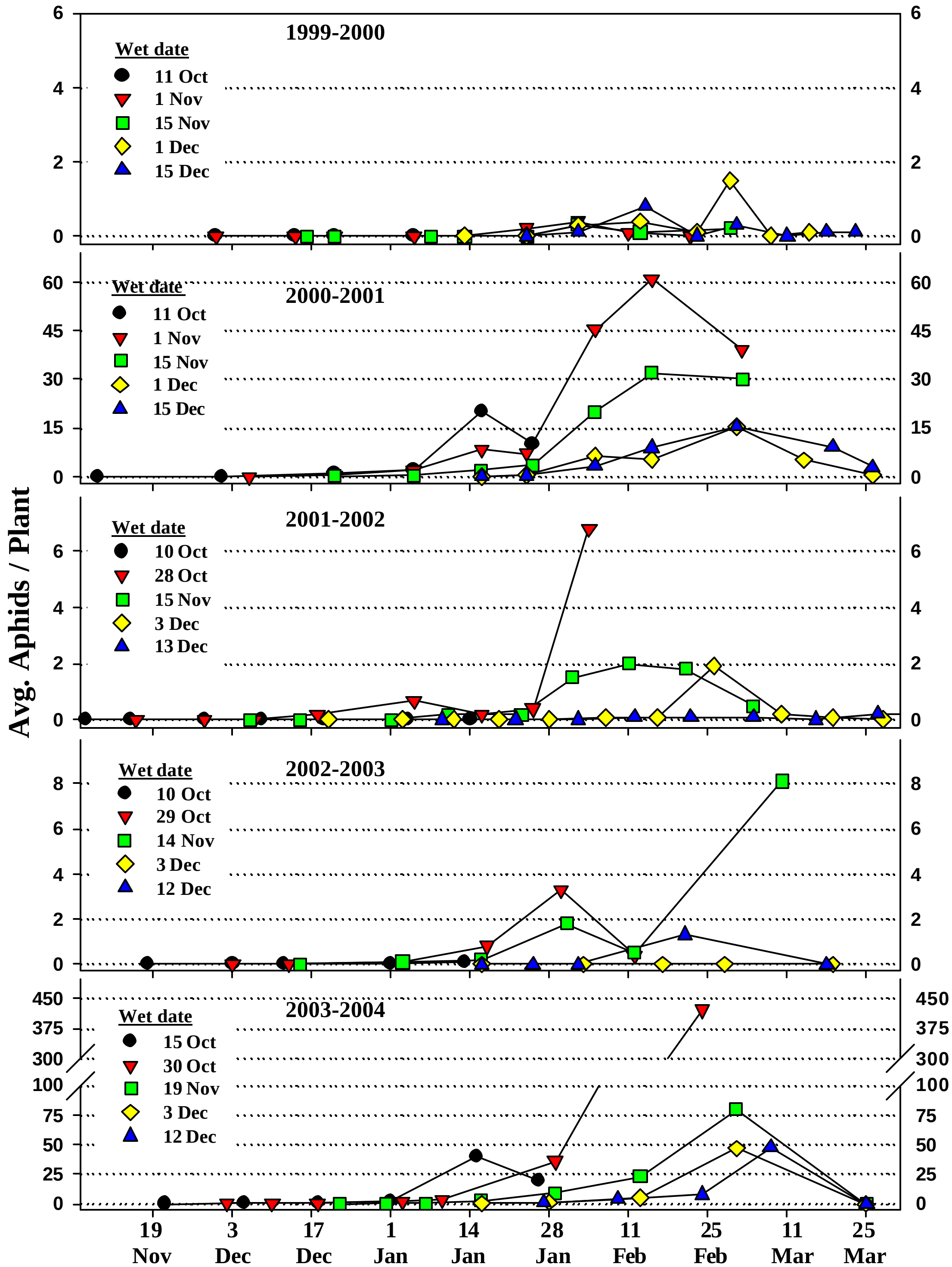


Figure 2. Potato aphid/ *Acyrthosiphon lactucae* populations in head lettuce each year in 5 plantings from 1999-2004.

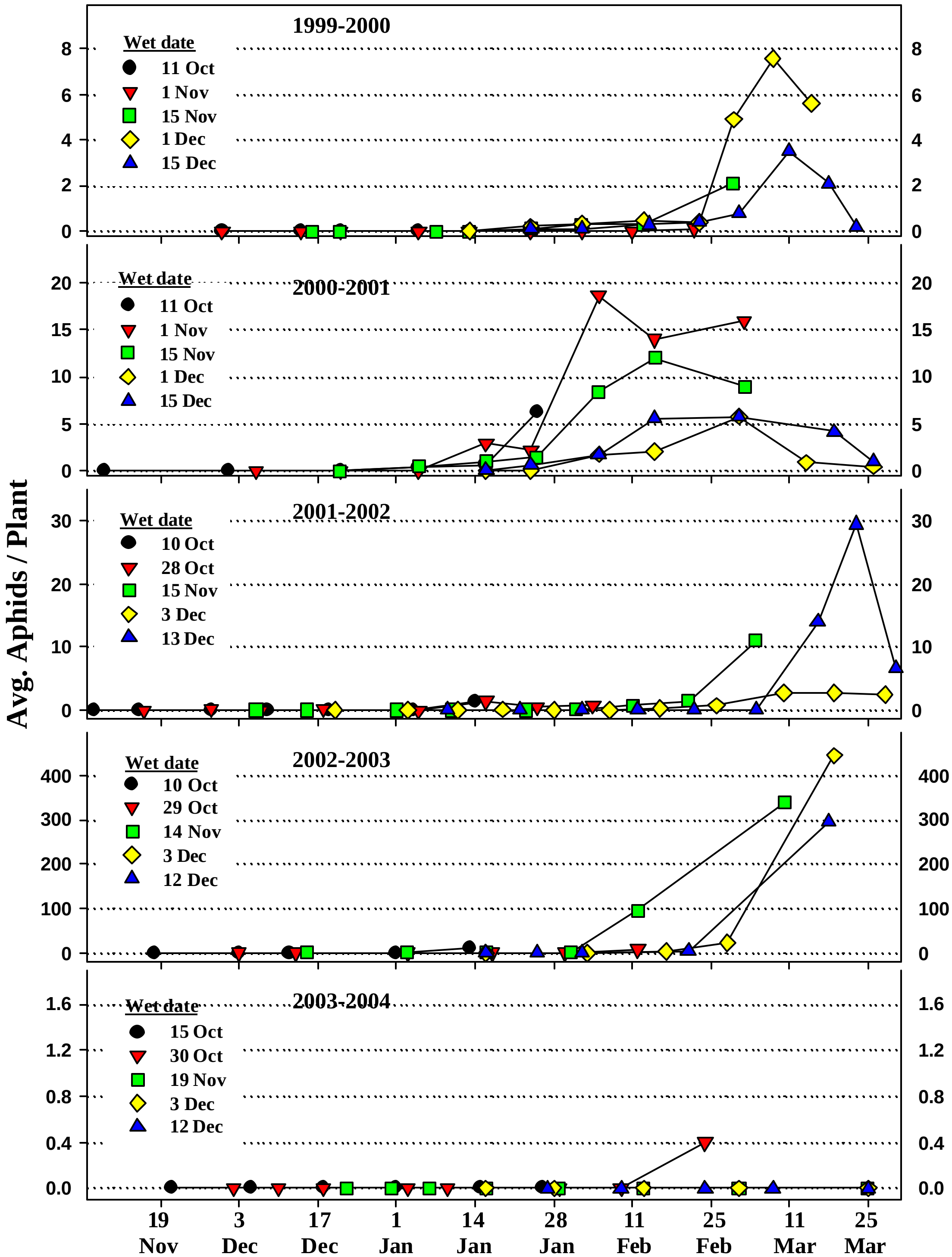


Figure 3. Lettuce aphid populations in head lettuce in 5 plantings each year from 1999-2004.

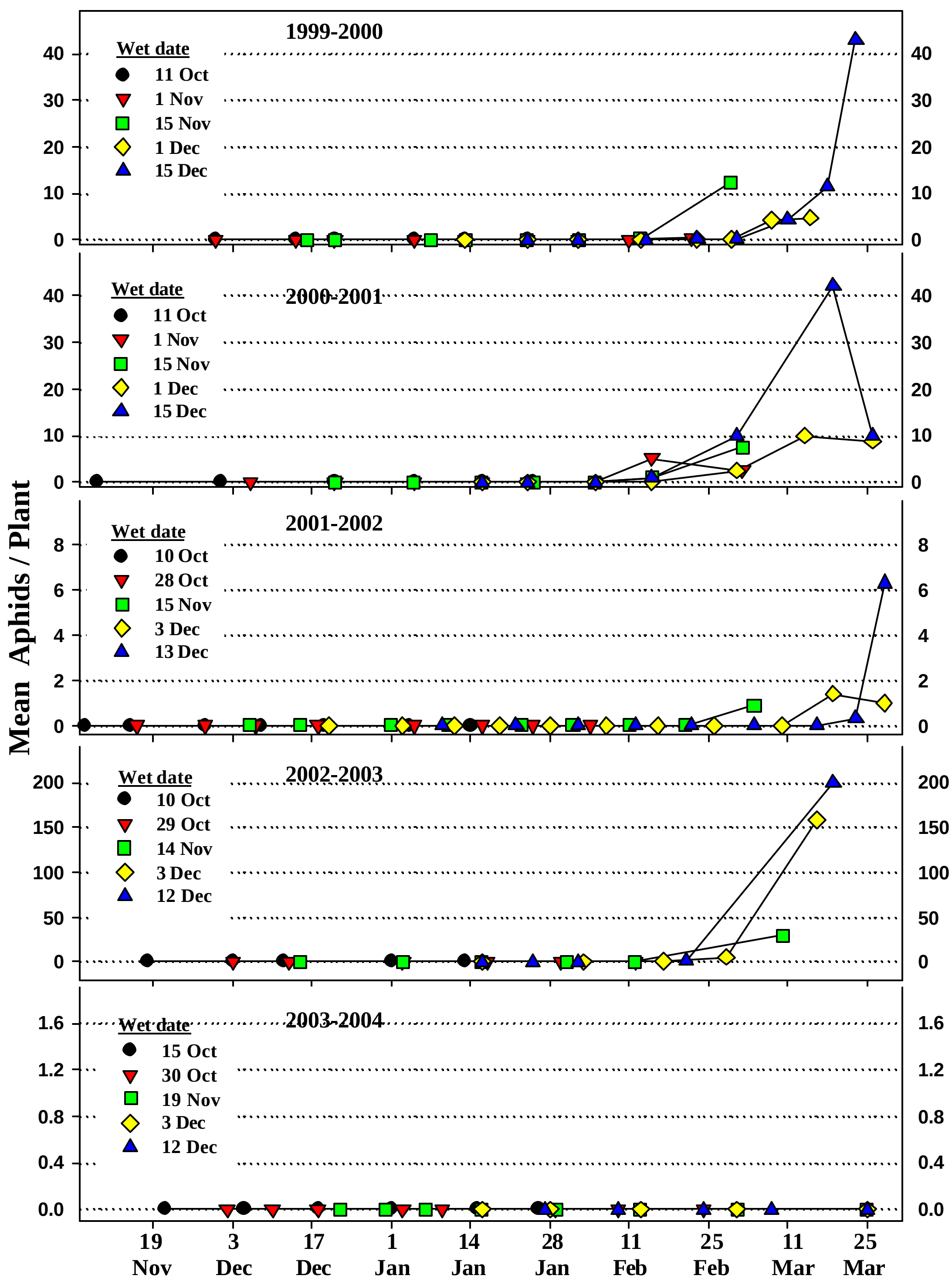


Figure 4. Foxglove aphid populations in head lettuce in 5 plantings each year from 1999-2004.

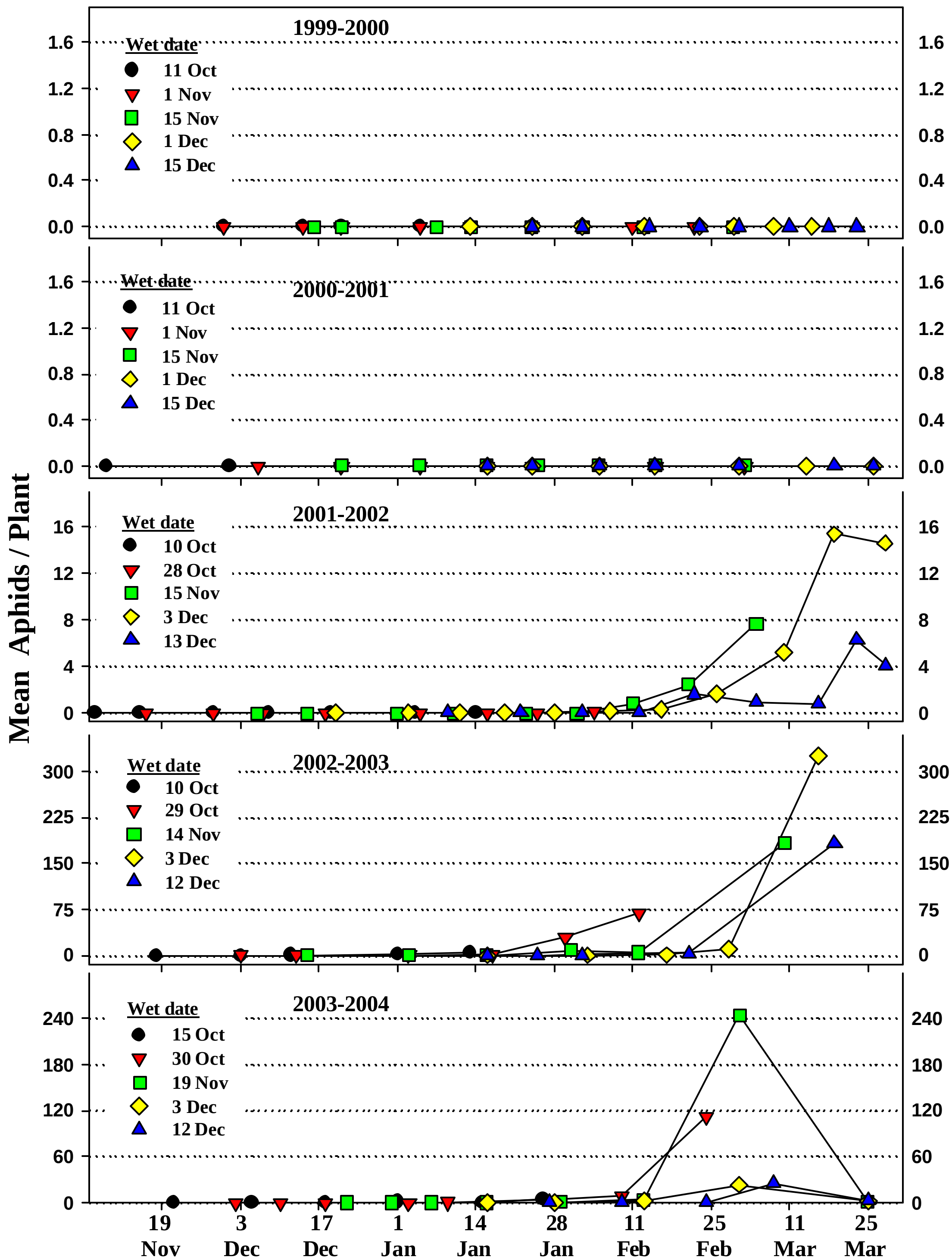


Table. 1 Aphid Contamination levels in lettuce heads and frame leaves at harvest in 5 planting each growing season from 1999-2004.

								Mean Apterous Aphids / Plant at Harvest					
				Temperature (ºF)			Rain	Green Aphid Complex [a]		Lettuce Aphid		Foxglove Aphid	
Season	**Wet date**	**Harvest**	**Variety**	**Max**	**Min**	**Avg**	**(inch.)**	**Head**	**Frame**	**Head**	**Frame**	**Head**	**Frame**
1999-2000	11-Oct	24-Jan	*Grizzley*	*81*	48	64	0	0	0	0	0	-	-
	1-Nov	20-Feb	*Wolverine*	*75*	45	58	0.1	0	0	0	0	-	-
	15-Nov	1-Mar	*Del Rio*	*75*	45	59	0.1	1.3	0.6	12.3	0	-	-
	1-Dec	23-Mar	*Jackel*	*73*	44	60	0.3	0.3	0.3	8.2	0.5	-	-
	15-Dec	23-Mar	*Diamond*	*74*	45	60	0.3	0.2	0.1	42.9	0.6	-	-
2000-2001	11-Oct	25-Jan	*Grizzley*	*74*	50	61	1.2	2	14.4	0	0	-	-
	1-Nov	2-Mar	*Wolverine*	*70*	45	57	1.16	15.2	38.5	5.1	0	-	-
	15-Nov	3-Mar	*Del Rio*	*70*	44	56	1.12	8.5	42.6	6.5	0.9	-	-
	1-Dec	26-Mar	*Jackel*	*72*	46	58	2.9	2.6	12.9	9.6	0.4	-	-
	15-Dec	26-Mar	*Diamond*	*73*	47	59	2.9	0.3	3.0	8.2	0.6	-	-
2001-2002	10-Oct	14-Jan	*Wolverine*	*78*	49	63	0.1	0	0	0	0	0	0
	28-Oct	4-Feb	*Grizzley*	*72*	44	58	0	0	2.3	0	0	0.3	0
	15-Nov	5-Mar	*Wolverine*	*74*	44	58	0	0.5	7.1	0	0	0	0.1
	3-Dec	22-Mar	*Diamond*	*72*	41	57	0	3.6	7.9	1.1	0.1	1.4	6.3
	13-Dec	6-Apr	*Diamond*	*73*	42	57	0	1.0	1.5	6.3	0.4	11.7	2.9
2002-2003	10-Oct	14-Jan	*Winterhaven*	*77*	47	59	0.03	0.4	3.5	0	0	0.5	3.4
	29-Oct	12-Feb	*Winterhaven*	*74*	45	59	1.27	1.1	6.9	0	0	2.4	48.1
	14-Nov	9-Mar	*Bubba*	*73*	45	59	1.27	96.6	244.6	44.7	16.4	33.9	150.9
	3-Dec	18-Mar	*Diamond*	*73*	44	58	1.23	105.5	345.6	145.7	21.4	125.9	201.3
	12-Dec	18-Mar	*Diamond*	*74*	45	59	1.23	126.2	170.9	182.2	18.9	81.8	101.0
2003-2004	15-Oct	26-Jan	*Honcho*	*75*	47	61	0.46	3.6	12.7	0	0	0.8	2.9
	30-Oct	24-Feb	*Bubba*	*70*	46	56	0.46	149.7	272.8	0	0	21.0	90.4
	19-Nov	16-Mar	*Coach Suprem*	*70*	43	56	0.36	0	0	0	0	0.7	0
	3-Dec	25-Mar	*Diamond*	*73*	44	58	0.36	0	0	0	0	1.3	0
	12-Dec	25-Mar	*Diamond*	*74*	45	59	0.36	0	0	0	0	2.2	0.4

[a] Green aphid complex consisting of *Acyrthosiphon lactucae* , potato aphid and green peach aphid

Table 2. Seasonal Avg. Green peach aphids / plant

Season	Wet date					5 Yr Avg
	11-Oct	30-Oct	15-Nov	3-Dec	15-Dec	
1999-2000	0.0	0.1	0.1	0.3	0.2	0.1
2000-2001	5.5	20.4	12.6	4.7	5.7	9.8
2001-2002	0.0	1.0	0.7	0.2	0.1	0.4
2002-2003	0.0	0.8	1.8	0.0	0.3	0.6
2003-2004	15.8	117.0	23.0	10.6	12.0	**35.7**
Avg	4.3	**27.9**	7.6	3.2	3.7	

Table 3. Seasonal Avg. Potato aphids [a] / plant

Season	Wet date					5 Yr Avg
	11-Oct	30-Oct	15-Nov	3-Dec	15-Dec	
1999-2000	0.0	0.1	2.5	3.5	1.0	1.8
2000-2001	1.3	6.7	4.6	1.6	2.7	3.4
2001-2002	0.2	0.4	1.5	0.8	5.6	1.7
2002-2003	2.3	1.4	72.2	94.2	60.1	**46.0**
2003-2004	0.0	0.1	0.0	0.0	0.0	0.0
Avg	0.8	2.2	16.2	**20.0**	13.9	

[a] includes *Acrythosiphum lactucae* populations

Table 4. Seasonal Avg. Lettuce aphids / plant

Season	Wet date					5 Yr Avg
	11-Oct	30-Oct	15-Nov	3-Dec	15-Dec	
1999-2000	0.0	0.1	1.6	1.2	4.4	1.8
2000-2001	0.0	1.0	1.2	3.1	9.1	2.9
2001-2002	0.0	0.0	0.9	0.2	0.7	0.4
2002-2003	0.0	0.1	5.1	32.8	40.2	**15.6**
2003-2004	0.0	0.0	0.0	0.1	0.5	0.1
Avg	0.0	0.3	1.8	7.5	**11.0**	

Table 5. Seasonal Avg. Foxglove aphids[b] / plant

Season	Wet date					5 Yr Avg
	11-Oct	30-Oct	15-Nov	3-Dec	15-Dec	
1999-2000	-	-	-	-	-	
2000-2001	-	-	-	-	-	
2001-2002	0.0	0.1	1.2	14.6	1.5	3.5
2002-2003	1.1	16.3	32.6	67.1	37.2	**30.9**
2003-2004	1.4	25.1	49.8	5.6	5.7	17.5
Avg	0.8	13.8	**27.9**	**29.1**	14.8	

[b] foxglove aphids not reproted prior to the 2001-2002 season

Objective 2. Foliar Activity of Assail, Fulfill and Flonicamid on Aphids

Materials and Methods

Small-plot, field studies were conducted in several head lettuce and broccoli plantings at the University of Arizona, Yuma Agricultural Center in the spring 2004 growing seasons. The objectives of these studies were to evaluate the efficacy of several new reduced risk insecticides for control of aphids. In each trial, lettuce or broccoli was direct seeded into double row beds on 42 inch centers and sprinkled beginning the following day. Plots for each trial consisted of 4 beds, 45-60' long with a two bed buffer between the plots. Plots were arranged in a randomized complete block design with 4 replications. Treatments and rates for each crop are presented in the data tables. Specific information for each trial is listed below:

Table 1. Experimental parameters for several aphid studies conducted in 2003/2004 art YAC.

	Head Lettuce I	Head Lettuce II	Head Lettuce III	Head Lettuce IV	Broccoli
Variety	Coach Supreme	Coach Supreme	Diamond	Diamond	General
Planting date	Nov 19	Nov 19	Dec 5	Dec 12	Dec 12
Harvest date	Mar 11	*NA*	Mar 22	*NA*	*NA*
Spray dates	1/13, 1/27, 2/19, 3/ 4	1/16, 1/23, 2/6	2/14, 2/28, 3/15	Mar 9, 16	2/9, 2/23, 3/8
Pre-spray aphid densities	8.0 / plant – GPA 0.0 / plant - FGA	0.7 / plant – GPA 0.0 / plant - FGA	5.2 / plant GPA 0.7/ plant - FGA	22.3 / plant GPA 4.7/ plant - FGA	59.4/ plant GPA

In the Lettuce I and II trials, and the Broccoli trial, at-planting soil applications of Admire were applied as a preplant injection at a depth of 1.5" below the seed line at bed shaping in 15 GPA final dilution. In all trials, foliar spray applications were hand applied with a CO_2 operated boom sprayer operated at 60 psi and 25 GPA. A directed spray (~75% band, with rate adjusted for band; nozzles directed inward toward the plants) was delivered through 3 nozzles (TX-12) per bed. An adjuvant was applied to all foliar treatments; DyneAmic at 0.065 % or 0.10 % v/v.

Aphid populations were assessed by estimating the number of aphids /plant in whole plant, destructive samples. Three aphid species were present on plants: Foxglove aphid (FGA), Green peach aphid (GPA) and *Acyrthosiphon lactucae* (no common name). On each sampling date, 5-8 plants were randomly selected from each plot and placed individually into large 5-gal tubs. Each plant was sampled by visually examining all plant foliage and counting the number of apterous (non-winged) aphids present. In the lettuce I trial, infestation levels of apterous aphids at harvest were estimated by randomly selecting 10 plants within each replicate, visually counting the number of aphids on frame/wrap per leaves and heads separately. The percentage of plants with greater than 5 aphids / head was also reported. Data for aphid abundance in all trials was analyzed using ANOVA (Proc GLM) and mean differences were estimated using a protected $LSD_{(0.05)}$.

Results and Discussion

Head Lettuce I: Aphid pressure was relatively heavy in this trial and peaked at harvest during early March. GPA was the dominant aphid species, particularly early, but FGA populations emerged at comparable levels at harvest. Foliar sprays were initiated at relatively high aphid densities (> 5 aphids / plant). However, both Assail and flonicamid provided excellent control following each application and maintained populations of both aphid species to low levels at harvest (Figure 1, Table 2). Fulfill provided good control of FG, but did not provide comparable protection of head contamination. Stretching the 2nd application for 21 days allowed the populations of GPA to build up to higher numbers than the other treatments. Both dimethoate and endosulfan did not provide comparable control following each application, and aphid contamination in the dimethoate treatment was inconsistent at harvest. The Provado and Admire treatment did not provide adequate protection form the FGA, but heads in the Admire treatments were free from GPA contamination at harvest (Table 2). Overall the Assail and flonicamid treatments provided the most consistent control.

Head Lettuce II: In this short trial, GPA was the primary aphid species peaking at 20 aphids / plant in mid Feb. FGA numbers were not significant (Table 3). Assail provided quick knockdown and sustained GPA at very low levels throughout the trial. Similarly Admire maintained GPA to negligible numbers. GPA number in the Capture+Dimethoate treatment were significantly lower than the untreated d check following each spray, but were higher than both Admire and Assail. The neonicotinoids provided the best control in this study.

Head Lettuce III: GPA was the dominant aphid species in the late spring lettuce trial, peaking at >45 aphids/plant in early March. The populations crashed thereafter to very low number at harvest as a result of unusually high temperatures (Figure 2). Similar to the first trial, aphid densities were allowed to build up to higher numbers prior to the first application (Table 1). As a consequence, the Fulfill treatments did not provide consistent control at 14 day spray intervals, (Table 3, Figure 3). Following the first application, the addition of Mustang with Fulfill significantly improved aphid control (Figure 2), but overall, the tank mix did not improve efficacy of GPA (Figure 3). In contrast, Flonicamid and Assail provided exceptional control for the duration of the trial, regardless of the addition of the pyrethroid or dimethoate. These two compounds provided the most consistent control (Figure 2, Table 4) and had significantly lower aphid numbers than all other treatments (Figure 3).

Head Lettuce IV: FGA and GPA was the primary aphid species peaking at > 30 aphids / plant at the beginning of the study (Table 5). Following the first application, flonicamid provided the most consistent knockdown of aphids, reducing GPA to significantly lower levels than either Assail or the Orthene+Capture treatment. All three treatments reduced FGA numbers to significantly comparable numbers. After the 2nd application numbers declined in all treatments and treatment differences were not observed among treatments for each species (Table 5). Flonicamid appeared to provide the most consistent knockdown activity of GPA and FGA.

Broccoli: GPA was the only aphid measured during this study and peaked following the 3 application in late March. GPA levels were very high when the first application was made, but nonetheless, both Assail and flonicamid significantly reduced infestations comparable to those found in the Admire treated plots (Figure 4). Non of the other foliar treatments, including Fulfill, were capable of significantly reduced aphid infestations following any of the treatments. However, the seasonal average number of GPA in both Fulfill and the OP rotation treatments were significantly lower than the untreated check (Figure 5). Flonicamid was the only foliar treatment than provided aphid control equitable to the standard Admire soil application.

Conclusions: Collectively, the chemical attributes and biological activities of Fulfill, Assail and flonicamid make them extremely attractive for implementation into an aphid management program. The past performance of these insecticides under experimental settings has shown that efficacy was highly dependant on spray timing. We know that initiating applications at low aphid densities (threshold of ~1 apterae / plant), particularly for Fulfill, has provided consistent protection to marketable heads. Fulfill did not perform well in the trials where sprays were applied above threshold levels. However, flonicamid and in most cases Assail, provided good economic control of FGA and GPA when sprays were initiated at densities above our nominal threshold. This is encouraging considering that most PCAs typically initiate sprays at or near threshold levels. Unfortunately, what we don't know is at what population density is *re-treatment* needed to sustain this level of protection from aphids? Can spray intervals be stretched to greater than 14 days and still achieve protection? Based on these studies, this might be possible for flonicamid and Assail, but not likely for Fulfill. Ultimately what PCA's need is a simp le action threshold that can be used in conjunction with a reliable sampling plan that will assist them in making cost-effective management decisions. In other words, they need a management-based approach that will prevent them from under-or-over applying these new insecticides, while producing a contaminant–free crop. Studies will be underway this next season to evaluate predetermined action thresholds for these aphid species which will allow us to provide cost-effective guidelines for the use of these products in the future.

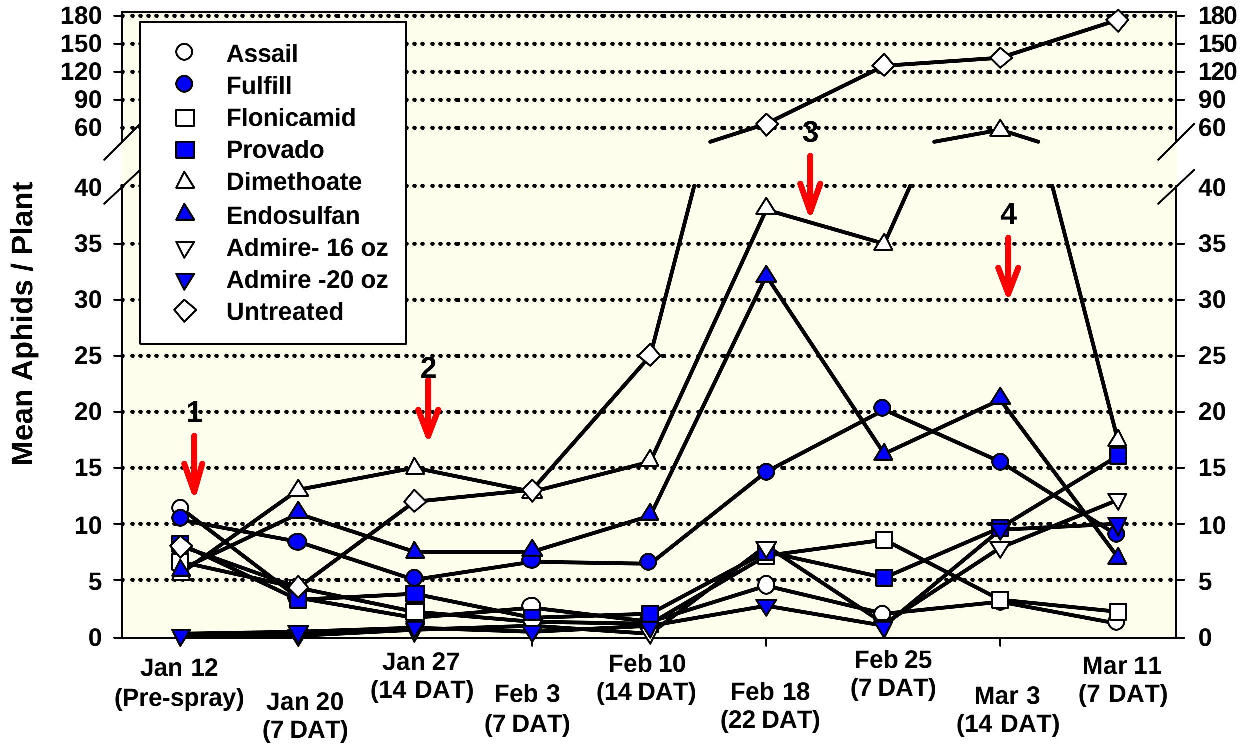


Figure 1. Aphid abundance on lettuce plants treated with various insecticides, YAC, spring 2004 – Head Lettuce I

Table 2. Aphid abundance and contamination on treated lettuce plants at harvest, YAC, spring 2004 – Head Lettuce I

		Avg. No. Aphids / Head			**% Contaminated Heads (> 5 aphids)**		
Treatment	**Rate**	**GPA**	**FG**	**Total**	**GPA**	**FG**	**Total**
Assail	1.7 oz	0.2 b	0.2 b	0.4 b	0.0 c	0.0 d	0.0 d
Fulfill	2.75 oz	2.0 b	0.0 b	1.9 b	14.8 b	0.0 d	9.5 cd
Flonicamid	2.3 oz	0.7 b	0.0 b	0.7 b	0.0 c	0.0 d	0.0 d
Provado	3.75 oz	1.4 b	4.0 b	5.4 b	9.5 b	29.5 b	33.3 b
Dimethoate	8 oz	2.2 b	0.5 b	2.7 b	14.8 b	4.8 cd	19.1 bcd
Endosulfan	32 oz	1.7 b	0.1 b	1.7 b	4.8 bc	0.0 d	4.8 cd
Admire	16 oz	0.1 b	7.1 b	7.2 b	0.0 c	24.1 b	28.6 bc
Admire	20 oz	0.3 b	3.0 b	3.3 b	0.0 c	28.9 b	28.6 bc
Untreated		23.0 a	34.1 a	57.1 a	80.2 a	52.4 a	100 a

Data was transformd log(x+1) before ANOVA ; untransformed means are presented in table. Means followed by the same letter are not significantly different , ANOVA, LSD $_{(p>0.05)}$.

Table 3 Aphid abundance on treated head lettuce plants following insecticide sprays, YAC, spring 2004 – Head Lettuce II

Treatment	Rate/ac	Mean GPA / Plant					
		Jan 23	Jan 30	Feb 6	Feb 14	Feb 21	Avg
Assail	1.7 oz	1.5 c	0.5 c	0.4 c	1.0 bc	1.4 c	1.2 c
Capture+Dimethoate	5oz + 12 oz	6.2 b	3.8 b	2.3 b	2.7 b	5.0 b	4.0 b
Admire	16 oz	0.0 c	0.2 c	0.6 c	0.1 c	1.1c	0.4 c
Untreated		9.9 a	16.3 a	9.3 a	14.6 a	20.0 a	13.9 a

Treatment	Rate/ac	Mean FG / Plant					
		Jan 23	Jan 30	Feb 6	Feb 14	Feb 21	Avg
Assail	1.7 oz	0.0 a	0.0 a	0.0 a	0.1 b	0.1 a	0.1 a
Capture+Dimethoate	5oz + 12 oz	0.0 a	0.0 a	0.0 a	0.1 b	1.1 ab	0.2 a
Admire	16 oz	0.0 a	0.4 a	0.4 a	0.2 b	5.2 a	1.2 a
Untreated		0.0 a	1.1 a	0.7 a	1.8 a	1.1 ab	0.9 a

Treatment	Rate/ac	Mean Total Aphids / Plant					
		Jan 23	Jan 30	Feb 6	Feb 14	Feb 21	Avg
Assail	1.7 oz	1.5 c	0.5 b	0.4 b	1.1 b	1.5 b	1.0 c
Capture+Dimethoate	5oz + 12 oz	6.2 b	3.8 b	2.3 b	2.8 b	6.1 ab	4.2 b
Admire	16 oz	0.0 c	0.6 b	1.0 b	0.3 b	6.3 ab	1.6 c
Untreated		9.9 a	17.4 a	1.0 a	16.4 a	21.1 a	13.2 a

Data was transformd log(x+1) before ANOVA ; untransformed means are presented in table. Mean followed by the same letter are not significantly different , LSD $_{(p>0.05)}$.

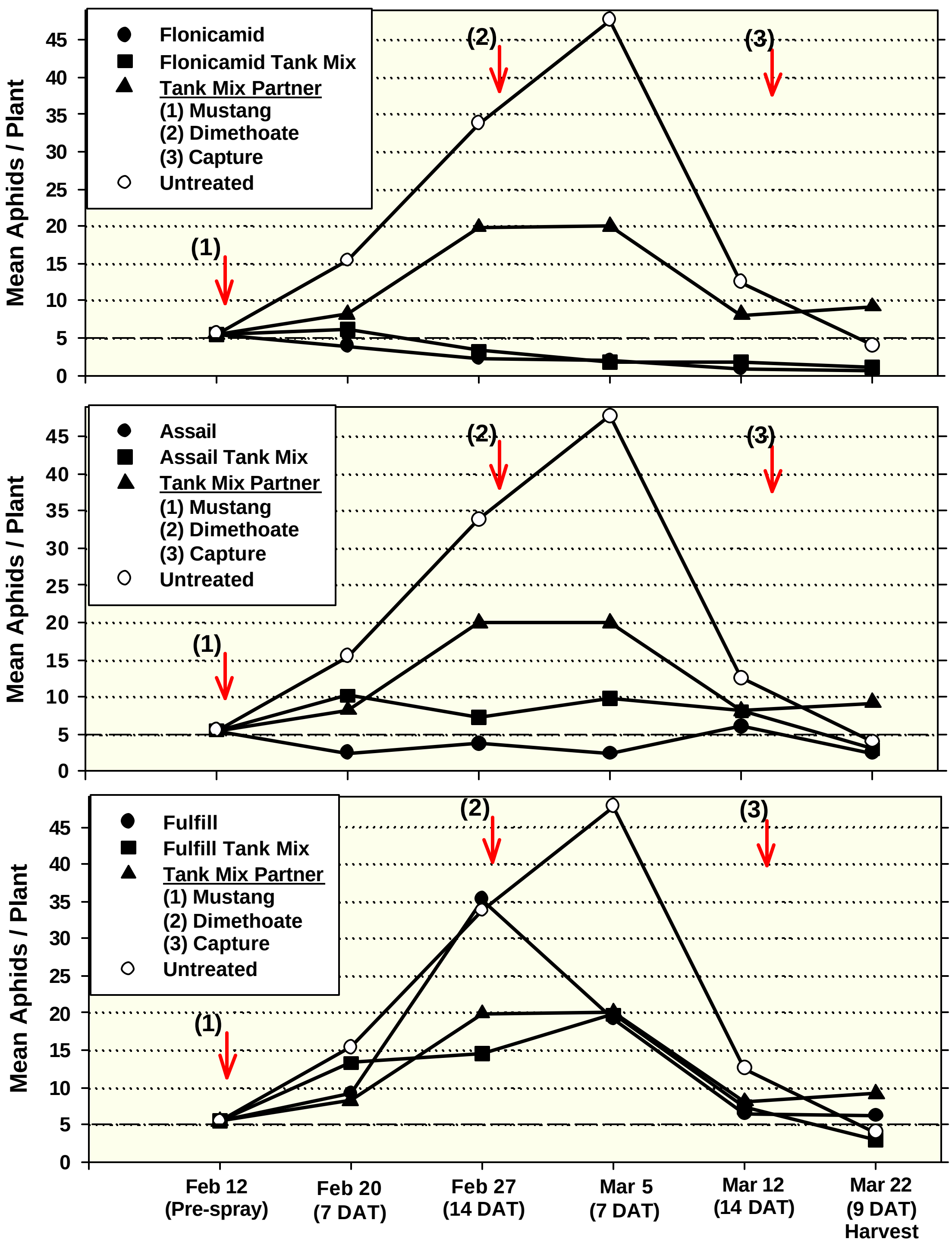


Figure 2. Aphid abundance on lettuce plants treated with various insecticides, YAC, spring 2004 – Head Lettuce III

Table 4. Green peach (GPA) and foxglove aphid abundance on treated head lettuce plants following insecticide sprays, YAC, spring 2004 – Head Lettuce III

	Avg no. GPA / Plant				
Treatment	**20-Feb**	**27-Feb**	**5-Mar**	**15-Mar**	**22-Mar**
Flonicamid	3.6 a	2.2 e	1.8 c	0.4 b	0.0 a
Flonicamid tank mix	5.2 a	3.3 de	1.7 c	0.5 b	0.0 a
Assail	1.9 a	3.3 de	1.7 c	1.7 b	0.0 a
Assail tank mix	6.4 a	5.9 cde	1.5 c	1.4 b	0.0 a
Fufill	9.2 a	22.6 bcd	8.8 bc	1.9 b	0.2 a
Fulfill tank mix	10.9 a	13.0 bc	14.3 b	2.0 b	0.0 a
Tank mix partner	7.8 a	17.6 ab	18.3 b	2.7 ab	0.2 a
Untreated	13.4 a	27.7 a	35.6 a	4.3 a	0.4 a

	Avg no. FGA / Plant				
Treatment	**20-Feb**	**27-Feb**	**5-Mar**	**15-Mar**	**22-Mar**
Flonicamid	0.3 a	0.1 a	0.2 b	0.4 a	0.6 a
Flonicamid tank mix	0.9 a	0.0 a	0.0 b	1.3 a	1.0 a
Assail	0.6 a	0.4 a	0.7 b	4.3 a	2.5 a
Assail tank mix	3.8 a	1.3 a	8.3 ab	6.7 a	3.0 a
Fufill	0.0 a	2.6 a	0.7 b	4.6 a	6.0 a
Fulfill tank mix	2.4 a	1.6 a	5.5 b	5.3 a	3.0 a
Tank mix partner	0.4 a	2.3 a	1.7 b	5.4 a	9.0 a
Untreated	2.0 a	5.1 a	11.5 a	7.8 a	3.1 a

Means followed by the same letter are not significantly different , ANOVA, LSD $_{(p>0.05)}$.

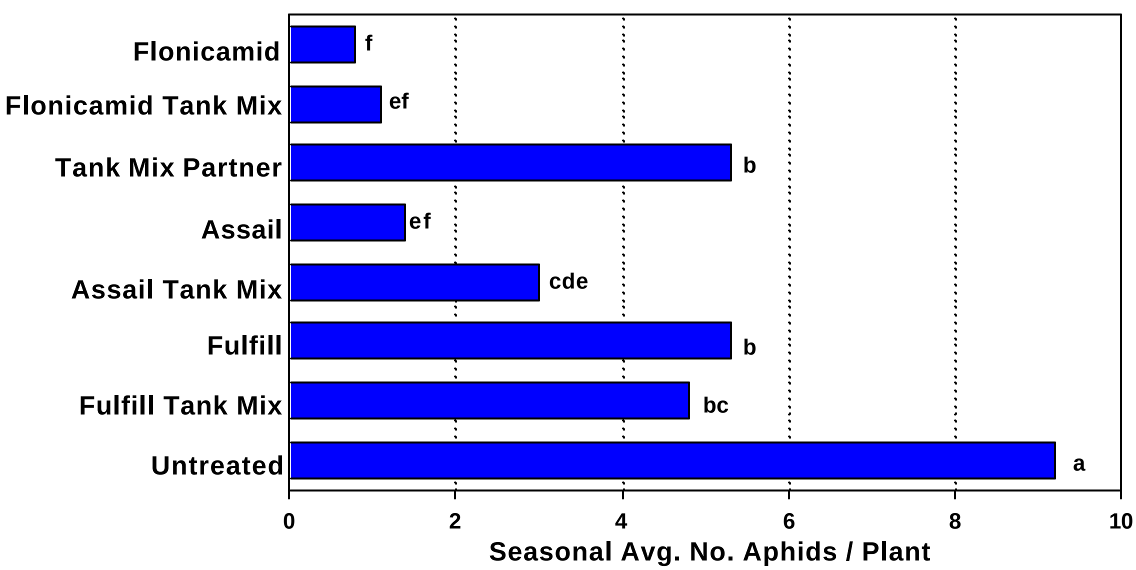


Figure 3. Seasonal aphid abundance on lettuce plants treated with various insecticides, YAC 2004, Head Lettuce III

Table 5 Green peach , foxglove aphid and *Acyrthosiphon lactucae* aphid abundance on treated head lettuce plants following insecticide sprays, YAC, spring 2004 – Head Lettuce IV

March 8 (Pre-spray counts)

		Mean Aphids / Plant			
Treatments	Rate/acre	Green Peach Aphid	Foxglove Aphid	*Acyrthosiphon lactucae*	Total Aphids
All treatments	-	22.4	5.9	4.5	32.9

March 16 (7 DAT#1)

		Mean Aphids / Plant			
Treatments	Rate/acre	Green Peach Aphid	Foxglove Aphid	*Acyrthosiphon lactucae*	Total Aphids
Assail	1.7 g	1.4 ab	7.5 b	0.0 a	8.8 b
Flonicamid	0.071 lb ai	0.0 b	3.1 b	0.0 a	3.1 b
Orthene+Capture	1 lb + 5 oz	4.1 a	3.9 b	0.0 a	8.0 b
Untreated	-	6.8 a	20.7 a	1.0 a	28.5 a

March 23 (7 DAT#2)

		Mean Aphids / Plant			
Treatments	Rate/acre	Green Peach Aphid	Foxglove Aphid	*Acyrthosiphon lactucae*	Total Aphids
Assail	1.7 g	0.0 a	6.3 a	0.0 a	6.3 a
Flonicamid	0.071 lb ai	0.0 a	1.3 a	0.0 a	1.3 b
Orthene+Capture	1 lb + 5 oz	0.1 a	8.3 a	0.0 a	8.4 a
Untreated	-	0.5 a	7.6 a	0.2.a	8.2 a

Mean followed by the same letter are not significantly different , ANOVA, LSD $_{(p>0.05)}$.

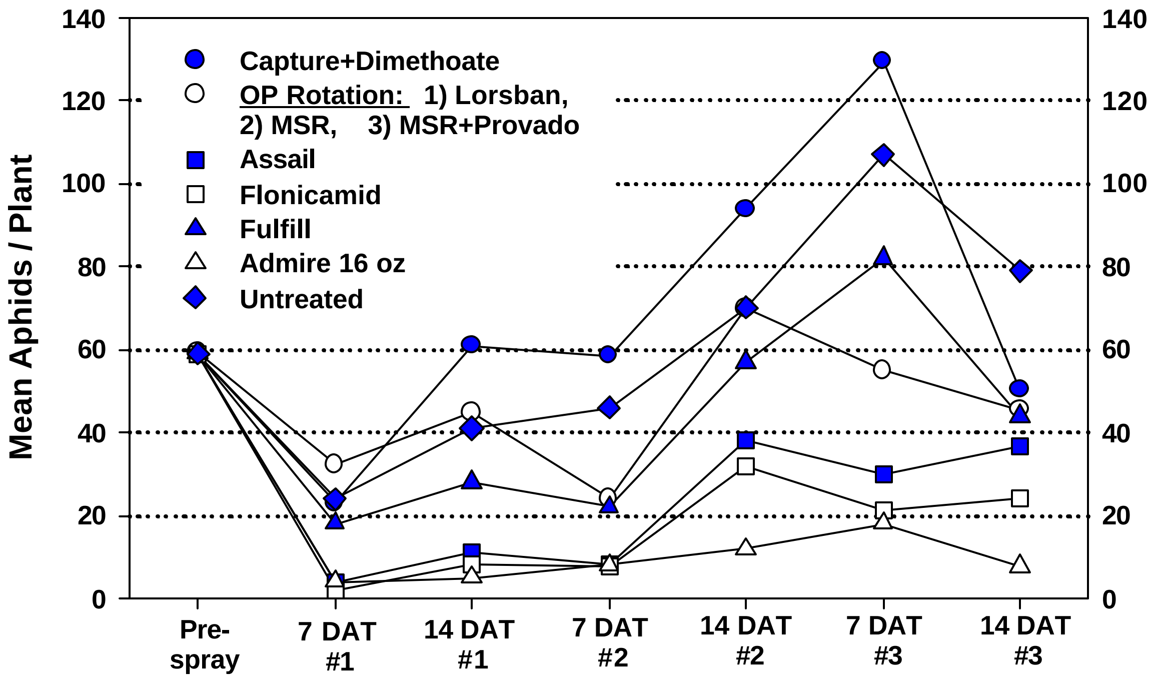


Figure 4. Aphid abundance on lettuce plants at various interval after spray treatments, YAC, 2004 – Broccoli.

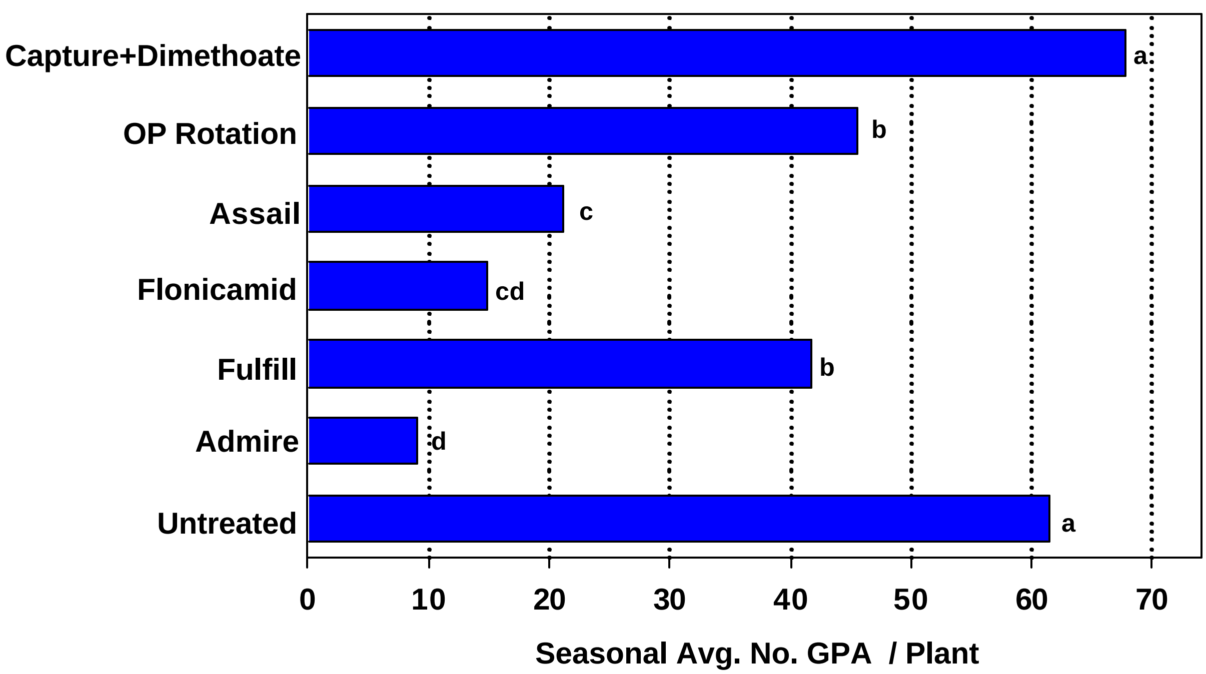


Figure 5. Seasonal aphid abundance on lettuce plants treated with various insecticides, YAC 2004, Broccoli

Objective 3. Seasonal Abundance of Thrips Populations in Head Lettuce

Materials and Methods

Studies to examine the spatial and temporal abundance of thrips populations were conducted on head lettuce at the Yuma Agricultural Center, Yuma, Arizona. Beginning in mid-September, 0.25 acre plots of head lettuce were planted at 2-2 week intervals. On each planting date (PD) lettuce was direct seeded into double row beds on 42 inch centers. Each planting was subdivided into 5 untreated plots and each plot consisted of 4 beds, 80 feet long. No insecticide applications were made during the study.

Thrips populations were assessed by estimating the number of thrips adults and larvae / plant by taking relative beat pan samples 4-5 times throughout each planting beginning at thinning and ending at harvest. On each sample date, four whole plants (n=20 per sampling date) were selected at random in each plot and individually removed from the soil at ground level. Plants were then beat vigorously against a screened pan for a predetermined duration (5-10 hits for upper and lower plant portion). The pan measured 2" H by 15" L by 8" W and covered with meshed screen with 0.5 spacing. Inside of the pan was a yellow sticky trap (6" by 6") to catch and retain dislodged thrips. On samples collected at harvest, counts of heads and frame leaves were conducted separately. Head samples consisted of the head, with cap leaf and 2 wrapper leaves. The head was then split in two and beat against the screen also. Frame leaf samples consisted of removing the head and 2 wrapper leaves and exposing as many leaves as possible while then beating the plant vigorously. Sticky traps were immediately covered with clear plastic and then taken to the laboratory where adult and larvae were counted under 10-20X magnification. Weather data was summarized for each sample date. Ambient temperatures for each AZMET site was prepared and provided graphically showing relative weekly trends across the season.

Results and Discussion

Seasonal population abundance of adult, larvae and total thrips during six lettuce planting dates over a three year period from 2001 to 2004 is shown in Figures 1-3. These data show that thrips reproduction and development on lettuce is largely influenced by temperature. This can be seen for each life stage within each planting where population abundance was greatest during the later lettuce plantings during Nov and Dec where temperatures averaged 60-65 degrees F. Population development was at its lowest level in the October plantings, particularly during the cooler winter periods. Although temperatures were quite warm during the March of 2004, thrips abundance was light, a consequence of unusually cool temperatures in January and early February. In contrast, greater development and abundance of thrips during the winter and spring in 2003, compared with 2002 and 2004, can largely be attributed to warmer temperatures in Dec, Jan and Feb.

This data suggests that during cool winters, October lettuce planting are at a lower risk of thrips infestation. However, this was not the case in 2003 due to mild winter conditions where all lettuce planting experienced significant thrips development and abundance. Table 1 shows the data for each year averaged across planting dates. This summary clearly shows the large abundance of thrips that occurred in 2003-2003 season, and strongly supports our contention that growers should be most cautious of thrips infestations in lettuce planted during November and December. Finally, this data demonstrates that western flower thrips are capable of reproducing and developing large population densities on head lettuce under winter and spring growing conditions in the desert.

Table 1. Western flower thrips per plant averaged across lettuce plantings and years, Yuma Agricultural Center

	Wet date						
Season	**17-Sep**	**10-Oct**	**30-Oct**	**15-Nov**	**2-Dec**	**15-Dec**	**3 Yr Avg**
2001-2002	43.3	23.6	16.9	37.0	40.2	65.9	37.8
2002-2003	41.7	45.7	66.2	111.8	75.9	66.8	***68.0***
2003-2004	14.1	22.8	25.9	22.7	19.5	35.0	23.3
Avg	33.0	30.7	36.3	***57.2***	45.2	***55.9***	

Figure 1. Seasonal Abundance of Western Flower Thrips Larvae in Several Plantings of Head Lettuce Relative to Average Daily Temperatures, Yuma Agricultural Center, 2001-2004.

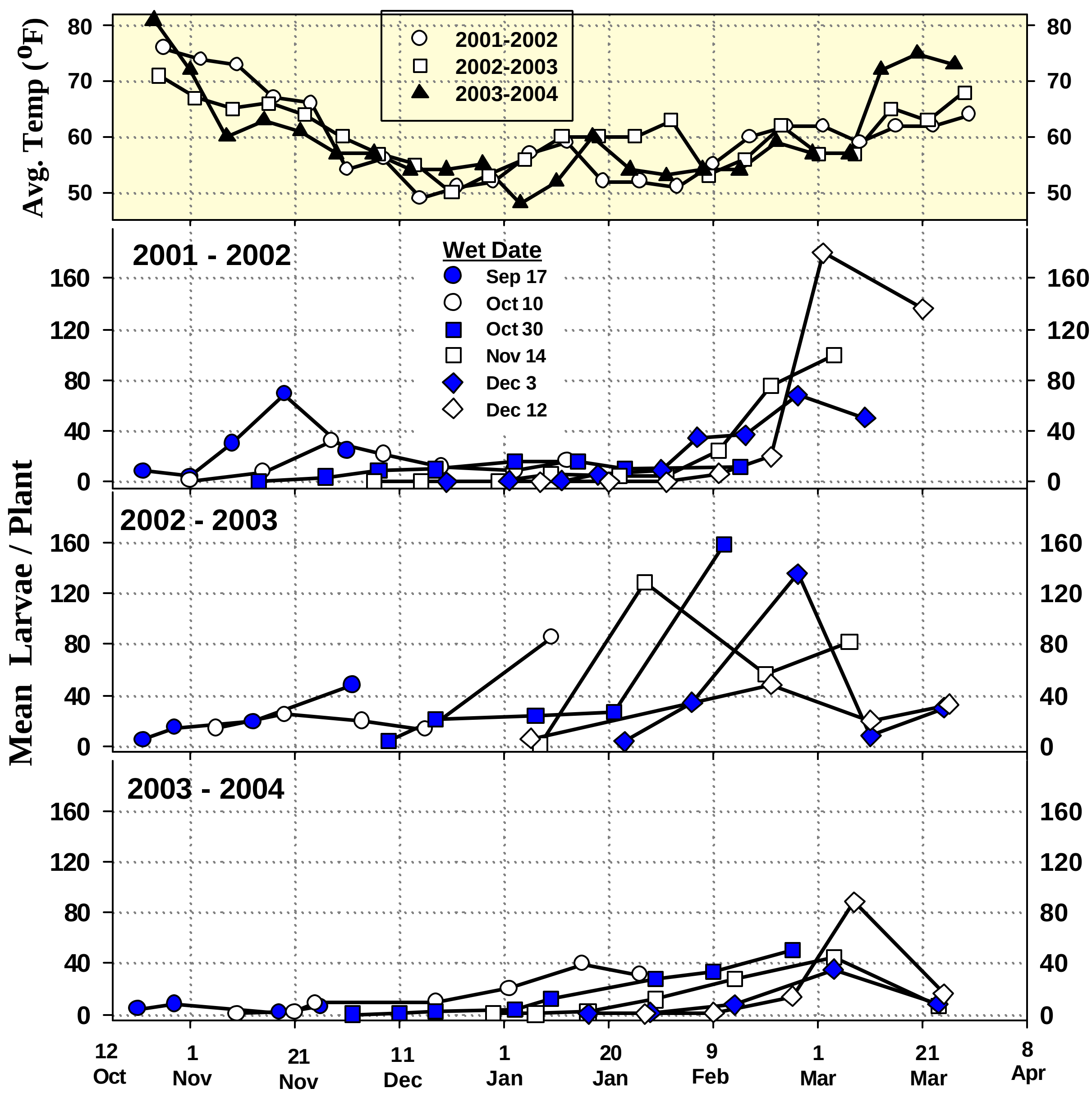


Figure 2. Seasonal Abundance of Western Flower Thrips Adults in Several Plantings of Head Lettuce Relative to Average Daily Temperatures, Yuma Agricultural Center, 2001-2004.

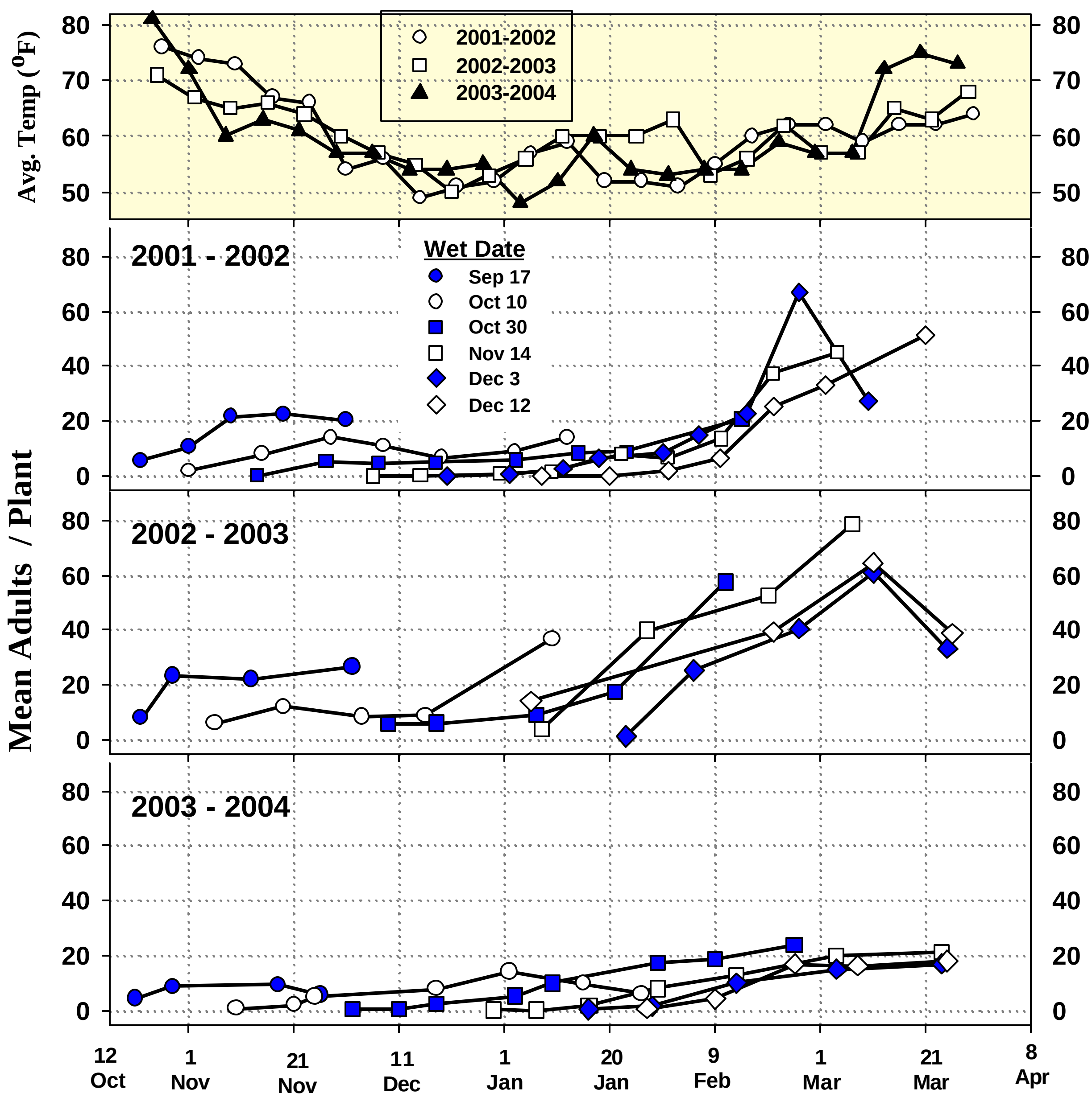
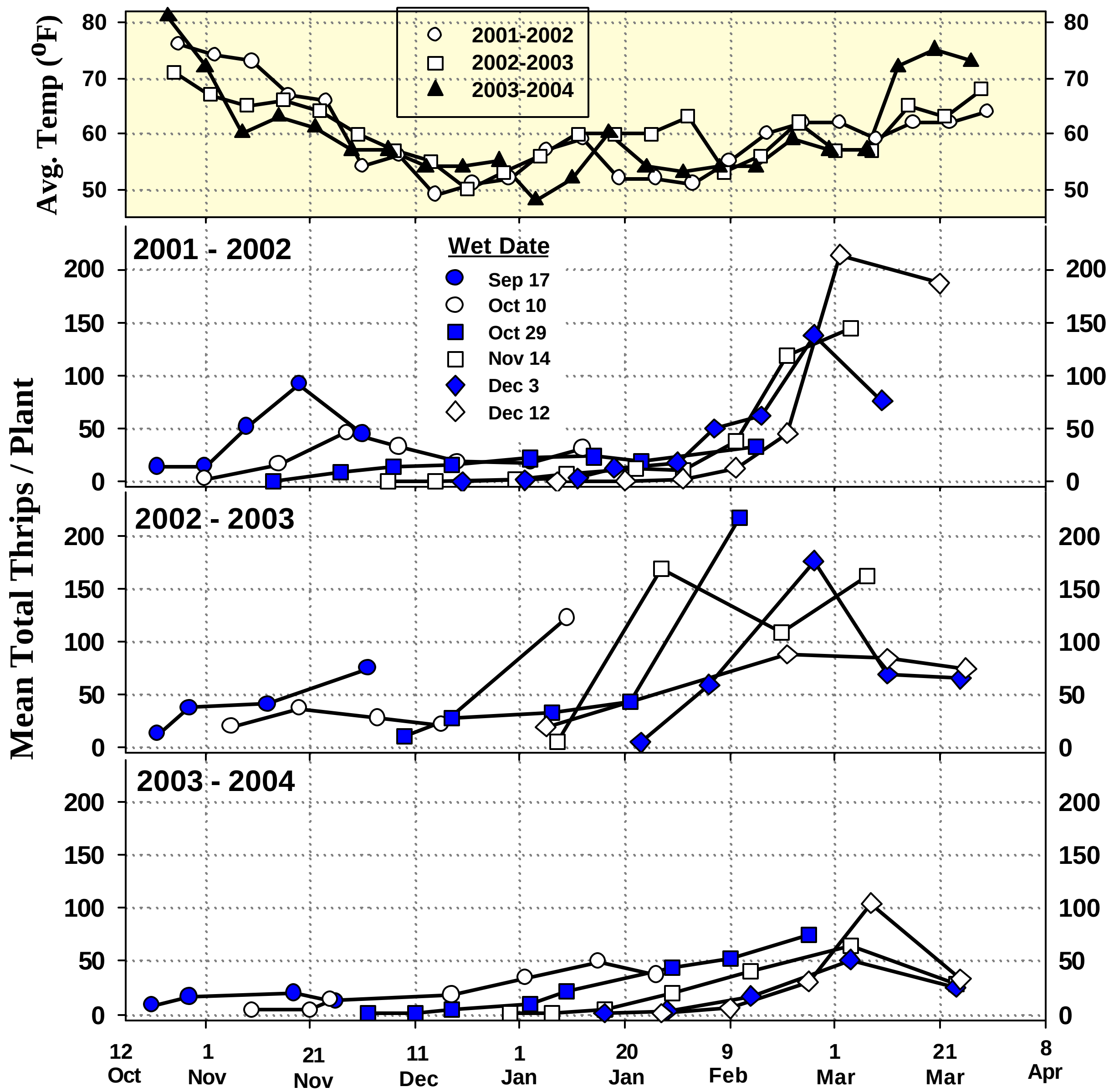


Figure 3. Seasonal Abundance of Total Western Flower Thrips (Adults and Larvae) in Several Plantings of Head Lettuce Relative to Average Daily Temperatures, Yuma Agricultural Center, 2001-2004.



Obj 4. Insect Pests in Yuma Lettuce: A Review of the 2003-2004 Season

Insect pest populations seemed to be exceptionally abundant on our desert vegetable crops this past growing season. It is difficult to explain why some insect populations occurred in larger numbers this year, but the weather we experienced may have had a significant role. Hot, dry weather in the early fall and spring, coupled with moderate winter temperatures provided ideal conditions for some insect pests. In other cases, pest pressure was down from previous years. Of course there are other biotic and abiotic factors (ie., natural mortality, cropping patterns, and pest control practices) that influence pest abundance, and those change from year to year.

Nonetheless, this report is an attempt to review the pest pressures we observed in the Yuma Valley during the 2003-2004 growing season. This was accomplished by summarizing data that we collected annually from untreated head lettuce plots and yellow sticky traps. What you will find in this report is a comparison of the abundance of whiteflies, worms, thrips and aphids this past season with numbers from previous years. Data for the most part is specific for the Yuma Valley and Yuma Ag Center where the studies were conducted, but in general the information should reveal trends and relative differences among insect pests for most Yuma growing areas.

Weather Patterns

Weather plays an important role in the development and regulation of insect populations. In particular, temperatures are the driving force for their biological development and behavior. Insects are poikliothermic (cold blooded), and thus generally develop more rapidly rate when temperatures are at 85-90 ºF. Insect flight, mating and ovipostional activity is generally greatest when temperatures are warm. Conversely, when temperatures are cool (ie., 50 ºF), biological activity is much slower. For example, beet armyworm larvae can complete development from a newly hatched 1st instar larvae to a pupa in about 7 days at temperatures averaging 86ºF, but would require almost 12 days to complete development at 75 ºF. But not all insects are the same. As you know, many of the aphid species that infest lettuce and cole crops are most active during the winter and spring when temperatures are cooler. However, they also have developmental limits that are influenced by a range of temperatures.

Rain and wind also influences insect population dynamics, usually by modifying their environment. Rain can influence the buildup of weeds and other alternate host that harbor large insect populations. Once the plants dry up, insects can disperse directly onto cultivated crops. Rain can also cause direct mortality to some insects that are washed off plants and suffocated in the soil. High winds can limit the insects ability to move or fly. A good example of this is the poor pollination by honeybees that occurs in windy conditions. Consequently, many of the differences in pest pressure we experience each season are determined to some degree by differences in weather conditions.

Figures 1 and 2 show average daily temperatures for the produce growing season during the past 6 years (Data was summarized from AZMET weather station located at the Yuma Ag Center, http://cals.arizona.edu/azmet/). Temperatures varied quite a bit from year to year during this period, and in some cases average temperatures varied as much as 15º F. In most cases it is difficult to see clear trends in temperature. However, what is very clear were the 2 extremes in temperatures experienced in 2003-2004. The first occurred during October where average daily temperatures were 10-15º F warmer than observed in the previous years (**Figure 1**). The second extreme occurred at the end of the 2004 growing season where similar differences were observed during much of March (**Figure 2**). As you will recall, both of these extremes had a marked influence on produce crop growth and maturity, and directly influenced the markets. Rainfall appeared to be less than average, where only the 2001-2002 season produced less rain (**Table 1**). This past season was unusual because most of our measurable rainfall occurred during November, which is generally a dry month. Finally, this past season seemed to be windier than normal, but AZMET measurements would suggest that it was not. Interestingly though, winds were light during the two temperature extremes in October and March. The significance of these weather extremes will be speculated upon in the discussions below.

Fig 1. Avg. Daily Temperatures during the 2003-2004 Fall-Winter Growing Season.

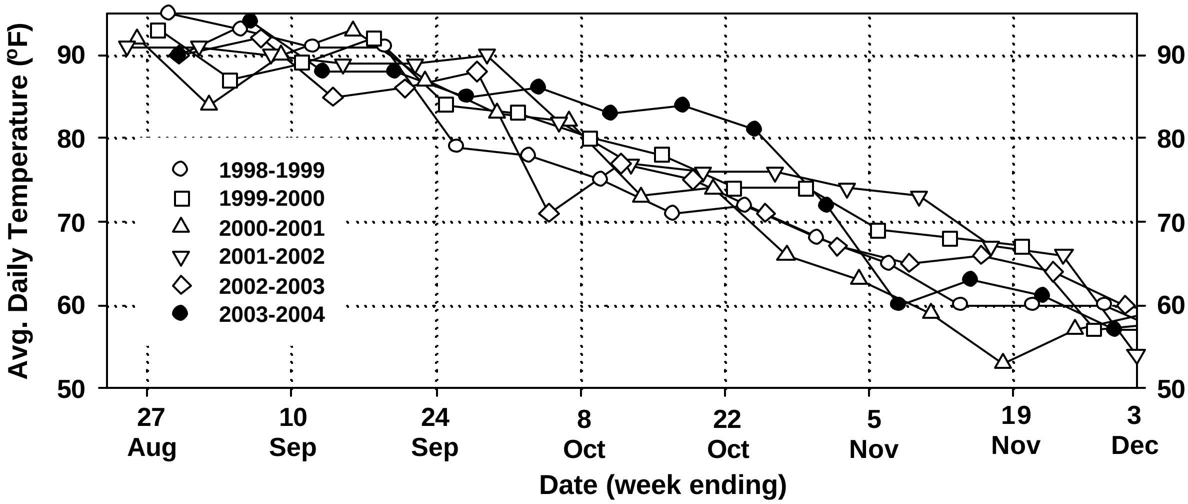
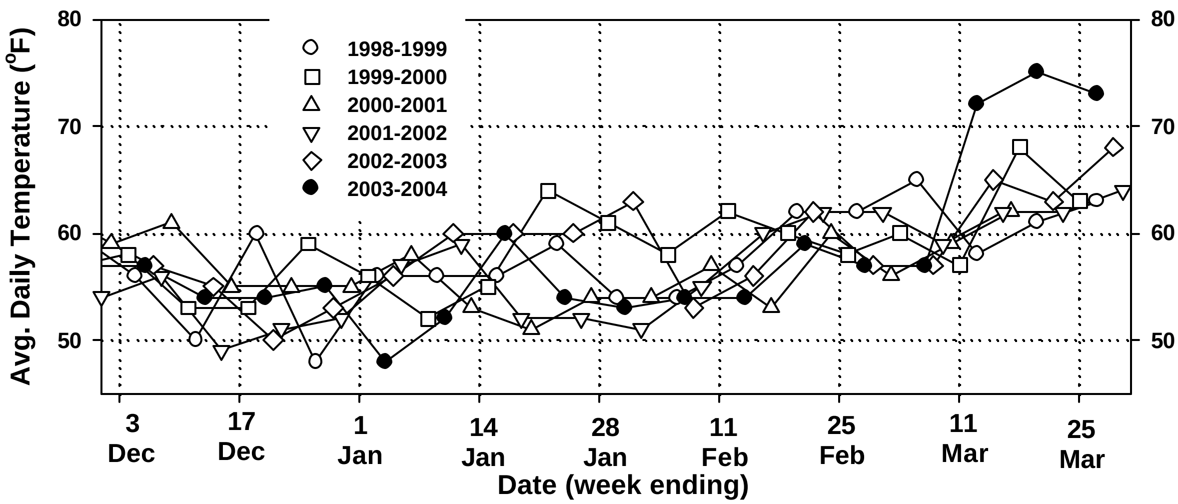


Fig 2. Avg. Daily Temperatures during the 2003-2004 Winter-Spring Growing Season.



T

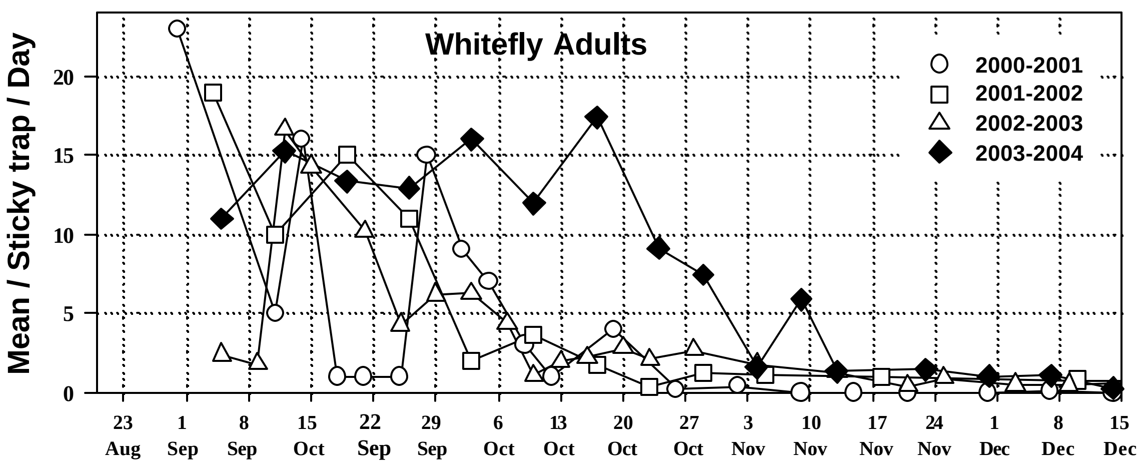
Table 1. Seasonal Avg. rainfall recorded at the Yuma Ag Center.

	Avg Seasonal Rainfall (in.)							
Yr	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Avg.**
98-99	1.01	0	0.26	0.05	0	0.53	0	1.85
99-00	0.80	0	0	0	0	0.05	0.21	1.06
00-01	0.02	0.63	0	0	0.31	0.02	2.54	**3.52**
01-02	0	0.10	0.01	0.01	0	0	0	0.12
02-03	0.02	0	0.02	0	0	0.57	0.64	1.25
03-04	0.05	0	0.40	0	0.10	0.20	0.10	0.85
Avg.	**1.9**	0.73	0.69	0.06	0.41	1.37	**3.49**	

Whiteflies

Based on our experiences over the past decade, whiteflies are most abundant during the fall. This is a result of their numbers building up on cotton and other crops during the summer when temperatures are ideal for biological development. As cotton and other crops are terminated, whiteflies disperse throughout the growing areas in search of suitable host plants like melons and cole crops. For several years we have placed yellow sticky traps in a grid from Gadsden to the North Yuma Valley throughout the season, collecting traps weekly and counting the number of whiteflies, aphids, leafminers and thrips on each trap. **Figure 3** below shows whitefly flight activity during the fall, as determined by sticky traps, over the last 4 years. Historically, we have observed that whiteflies move throughout the area in August and September. We typically experience a considerable decline in movement in October when temperatures begin to decline. However, last fall flight activity extended well into October as illustrated in **Figure 3**. It is probably no coincidence that these extended flights correlate strongly with the higher temperatures we experienced in October **(Figure 1).** These temperatures also allowed for rapid whitefly development on our cole crops and melons where we observed high densities infesting untreated crops. Another factor which may have influenced this movement was the light winds that were associated with the higher temperatures. Winds averaged less than 4 mph during the first 3 weeks in October, compared to previous years when winds consistently averaged over 6 mph (AZMET).

Fig. 3 Whitefly Flight Activity Based on Yellow Sticky Traps Catches, Yuma Valley (2000-2004)



Worms (Beet Armyworm and Cabbage Loopers)

Without a doubt, the fall of 2003 was one of the heaviest worm years that we've seen in quite a while. Anecdotal reports of PCA's spraying insecticides to control beet armyworm (BAW) and/or cabbage loopers (CL) twice a week were common during September and October. There was good reason for this. Historical data generated from the untreated controls of small plot efficacy trials conducted similarly each season from 1997 to 2003 at the Yuma Ag Center shows the large numbers of worms present on lettuce plants in 2003 compared with previous years **(Figure 4).** At their peak, BAW and CL averaged almost 16 larvae / plant. That's a lot of worms. Again, higher than average temperatures (**Figure 1**) likely influenced the buildup of this unusually large abundance of worms. Worm pressure usually subsides during October when the weather breaks. However as shown in **Figure 5** average daily temperatures in 2003 remained at or near 85 ºF during most of October resulting in 3-4 times greater numbers of worms than measured in our 2002 trials. Average daily temperatures differed by as much as 15 ºF during this time. Worm pressure finally declined as temperatures broke in late October. Consequently, we are convinced that the high worm pressure seen on fall produce in 2003-2004 was directly influenced by weather. Temperatures had a significant impact on worm abundance by accelerating larval development on plants. Larvae were able to complete development at a more rapid rate (optimal temperature for development has been shown to be 86 ºF). This resulted in more generations of worms than normally observed. Furthermore, higher night time temperatures likely provided an ideal environment for moth flight and oviposition. This would result in greater egg lays. It was not unusual to see multiple eggs and egg masses on larger plants throughout October. Finally, as discussed above, the light winds probably enhanced moth flight activity.

Fig 4. Worm populations (total larvae / plant) in <u>untreated</u> head lettuce over several experimental trials per season, Yuma Ag Center (1997-2004)

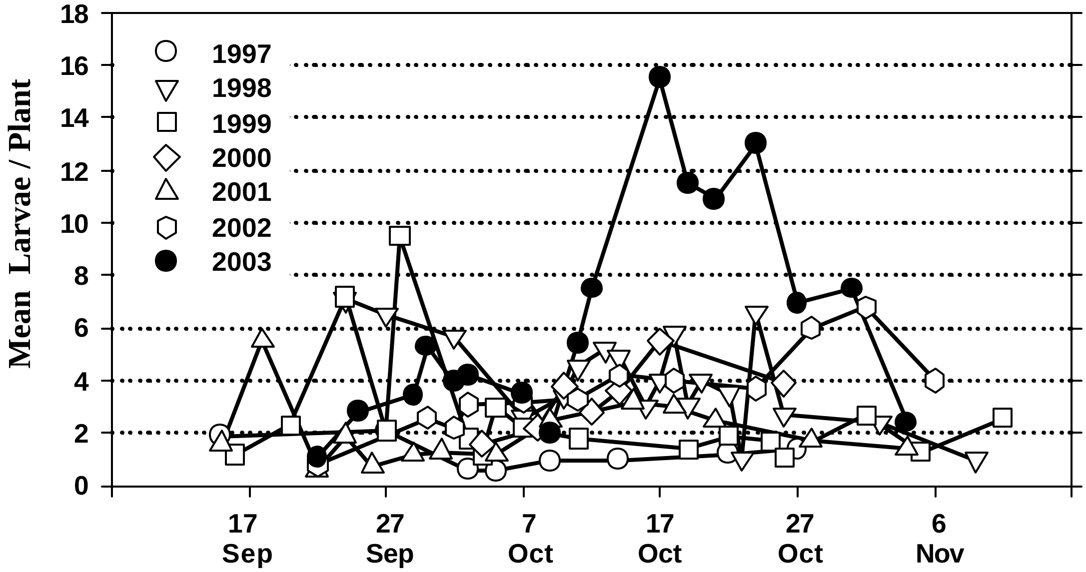
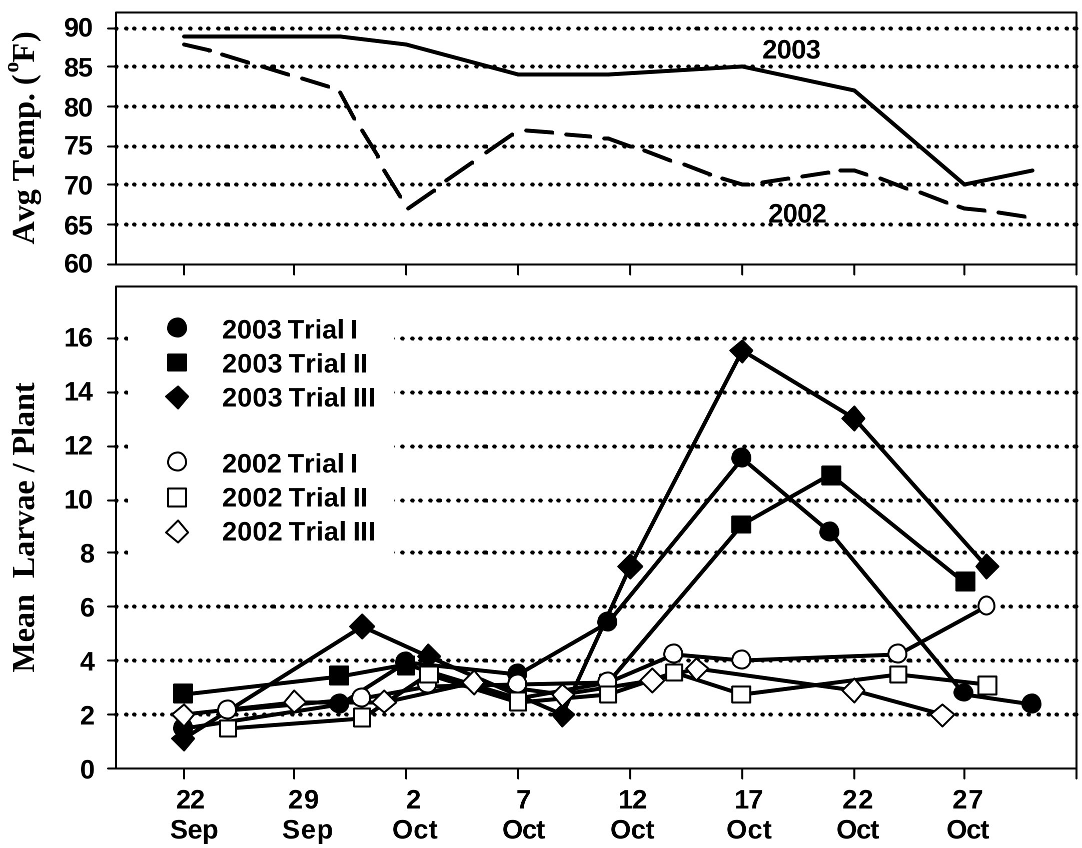


Fig 5. Total worm populations (small and large beet armyworm and cabbage looper larvae) relative to temperatures in untreated head lettuce plots at the Yuma Ag Center, 2002-2003



Western Flower Thrips

Over the past several years western flower thrips has become a common and often serious pest of lettuce. However, thrips abundance in Yuma lettuce during 2003-2004 was lighter than what we have experienced the past several years. We have been conducting trials at the Yuma Ag Center for the past several years to study the influence of planting dates on thrips population growth. **Figure 6** shows the results of those studies to date. Thrips abundance never exceeded greater than 100 thrips /plant last season with the exception of 1 planting (Dec 12 wet date). However, thrips populations exceeded 100/plant in 3 and 4 plantings respectively in 2002 and 2003. Thrips pressure is generally low during Nov, Dec and Jan, the exception occurring during 2002-2003 where populations grew at rapid rates during this period. This can be explained in part to higher temperatures during the winter, particularly in January, 2003 (**Figure 2**). Temperatures may have also influenced thrips flight activity as shown in **Figure 7**. Trap catches of thrips were similar throughout the Yuma Valley for all years until late in the season. This year thrips dispersal at the end of the season was relatively lower than what we've seen in past years. Also, anecdotal reports from PCA's suggest that thrips pressure was lighter this year. This may be due to some extent to high temperatures in March, but was more likely a result of heavy insecticide usage for aphids, and difference in cropping patterns. In general, we feel that thrips abundance and flight activity is generally highest in March as a result of optimal temperatures for development and flight, the rapid harvest of lettuce, and the reduced number of produce acres (**Figures 6 and 7**). Finally, to confirm what most PCA's and growers already believe, our data set suggests that thrips population development in lettuce is generally greatest in late-November and December plantings.

Fig 6. Seasonal Western Flower Thrips Populations in Several Plantings of Head Lettuce , Yuma Ag Center, 2000-2004

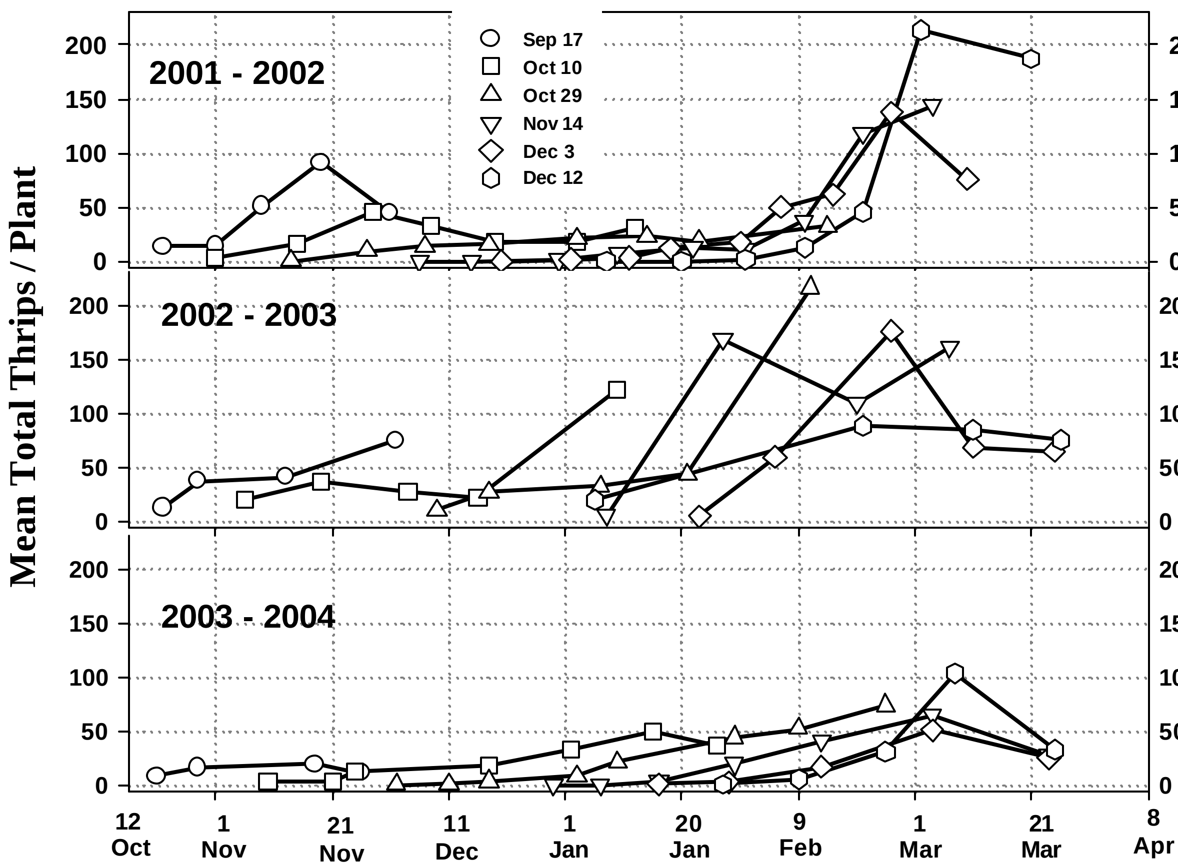
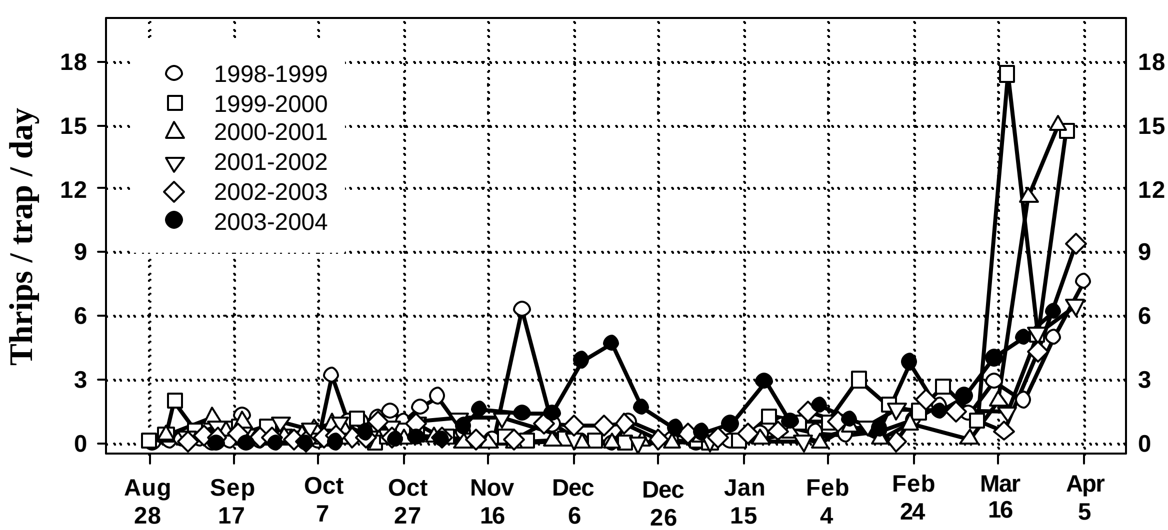


Fig 7. Thrips Flight Activity Based on Yellow Sticky Trap Catches, Yuma Valley 1998-2004



Aphids

Aphid pressure was heavy for a second consecutive year in 2003-2004. Surprisingly, green peach aphids (GPA) were the predominant species throughout the area, relative to the last few years where it has been almost non-existent. PCA's reported seeing GPA colonizing lettuce and cole crops in early November. Many populations required insecticide treatments to prevent economic infestations. Similar to our work with thrips, we have been conducting trials at the Yuma Ag Center for the past several years to study aphid population development across the season in several lettuce plantings (not treated with insecticide). The results from this work showed that over the past 5 growing seasons GPA populations were greatest last year , with GPA peaking at over 400 / plant at harvest in our early November planting window (**Figure 8**). GPA continued to be abundant throughout the spring until March when populations quickly crashed due to high temperature (**Figure 2**). We are not certain why GPA was so abundant in 2004, as we are not sure how temperatures influence population growth during the winter. Average daily temperatures ranged between 50-55F for most of Dec, Jan and Feb, but it is more likely that the unusual GPA abundance in 2004 was a result of a complex of both abiotic and biotic factors.

Comparisons within wet dates show that seasonal aphid abundance differed by species. Whereas GPA appears to be prevalent in early November plantings, potato aphids are heaviest in late –November to early- December plantings. Potato aphids were particularly heavy in 2003 as was lettuce aphid and foxglove aphids. Lettuce aphid tends to be most abundant late in the season when temperatures average >60F. Although we only have 3 years for foxglove aphids, our information suggests that this aphid species has the wide range of activity. Compared with the other aphids, foxglove aphid has occurred in large number throughout the November and December plantings. Although we have seen heavy aphid pressure on produce the past 2 seasons, we less certain as to what factors contributed to these outbreaks. As we collect more data, we may be able to associate cropping practices or weather patterns that influence their abundance.

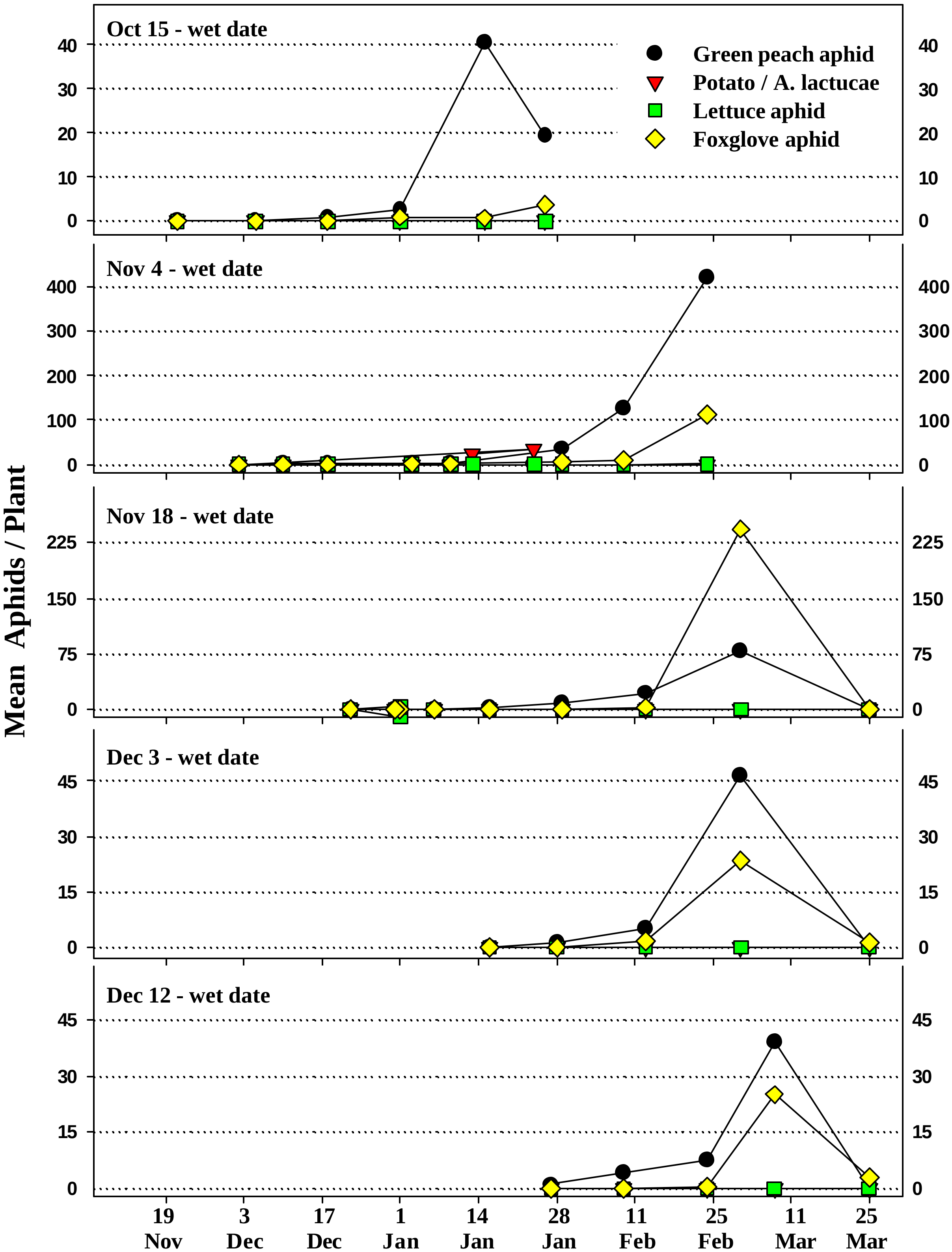

Oct 15 - wet date
Green peach aphid
Potato / A. lactucae
Lettuce aphid
Foxglove aphid
Nov 4 - wet date
Nov 18 - wet date
Dec 3 - wet date
Dec 12 - wet date
Mean Aphids / Plant
19 Nov
3 Dec
17 Dec
1 Jan
14 Jan
28 Jan
11 Feb
25 Feb
11 Mar
25 Mar

Fig 8. Seasonal population trends for Green Peach Aphids in untreated head lettuce for three planting windows over a five year period, YAC